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(54) **A HEAT EXCHANGER**

(57) A heat exchanger (1) adapted for circulation of a first fluid therein comprising a first manifold group (100) and a second manifold group (200) arranged substantially in parallel with respect to each other, a plurality of tubes (500) extending between the first manifold group (100) and the second manifold group (200), and a third manifold group (300) arranged either at the level of the first manifold group (100), or at the level of the second manifold group (200), also being connected to the plurality of tubes (500), wherein the tubes (500) are arranged in a first stack (501) and a second stack (502), the third manifold group (300) enabling a first fluid U-flow therebetween, wherein the first manifold group (100) comprises two primary fluid compartments (101A, 101B) so that the first primary fluid compartment (101A) is connected directly to the first stack (501), and the second primary fluid compartment (101B) is connected directly to the second stack (502), the first primary fluid compartment (101A) comprising a first fluid inlet channel (180A), and the second primary fluid compartment (101B) comprising a first fluid outlet channel (190A), wherein the second manifold group (200) comprises two secondary fluid compartments (201A, 201B) so that the first secondary fluid compartment (201A) is connected directly to the first stack (501) and the second secondary fluid compartment (201B) is connected directly to the second stack (502),

wherein an inlet pass (P_{in}) is formed between the first fluid inlet channel (180A) and the first secondary fluid compartment (201A), and wherein an outlet pass (P_{out}) is formed between the second secondary fluid compartment (201B) and the first fluid outlet channel (190A).

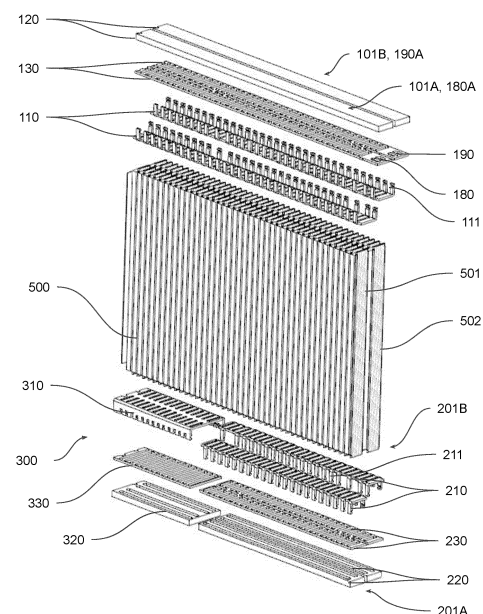


Fig. 3

Description

FIELD OF THE INVENTION

[0001] The invention relates to a heat exchanger. In particular, the invention relates to the heat exchanger for a motor vehicle.

BACKGROUND OF THE INVENTION

[0002] The present invention relates to the field of heat exchangers, for example to heat exchangers intended to be traversed by a fluid under high pressure. In this respect, the invention relates more particularly to air conditioning gas coolers, inner gas coolers or evaporators capable of being traversed by a refrigerant fluid in the supercritical state, as is the case for natural gases such as carbon dioxide, also known as CO₂ or R744. Further, the invention relates to heat exchangers adapted for operation is inner condensers, adapted to work with refrigerants like R134a or R1234yf. Such heat exchangers find particular application in motor vehicles. More particularly, the invention relates to the heat exchanger comprising manifold groups.

[0003] A known fluid refrigerant circuit forms a closed loop in which the refrigerant fluid flows in order to dissipate or collect calories through heat exchangers. The heat exchanger comprises the manifold to connect said heat exchanger to the fluid refrigerant circuit, said manifold linking pipes from the fluid refrigerant circuit to the heat exchanger core, in order for the refrigerant fluid to flow through heat exchanger tubes.

[0004] In a fluid refrigerant circuit traversed by a refrigerant fluid in the supercritical state, this refrigerant fluid remains essentially in the gaseous state and under a very high pressure, which is usually around 100 bars for R744. As a result, heat exchangers must be able to withstand such high pressure, the recommended burst pressure being generally three times the value of the nominal operating pressure, burst pressure thus reaching around 300 bars. Burst pressure for R1234yf refrigerant-based circuits is considerably lower.

[0005] Known heat exchangers comprise manifolds and heat exchange tubes allowing the refrigerant fluid to migrate between the manifolds. The heat exchange tubes also allow a thermal exchange between the refrigerant fluid, flowing inside said heat exchange tubes, and an air flowing outside the heat exchanger, thus capturing calories from the air flowing across the heat exchanger core. The manifold comprises a first manifold intended to receive the refrigerant fluid from the fluid refrigerant circuit and a second manifold intended to inject the refrigerant fluid from the heat exchanger back into the fluid refrigerant circuit.

[0006] The manifold comprises a cover, a header plate and a distribution plate localized between the cover and the header plate. The cover of the manifold is configured to delimit said manifold. The header plate of the manifold

is designed to allow the refrigerant fluid to flow between the first manifold or the second manifold and the heat exchange tubes. The distribution plate is intended to allow the refrigerant fluid to flow between a connector connected to said distribution plate and the header plate.

[0007] The cover, the distribution plate and the header plate are brazed together to insure the sealing of the manifold, avoiding leaks of the refrigerant fluid. The header plate comprises teeth configured to secure the assembly of the header plate, the distribution plate and the cover together, in order to help the brazed manifold to withstand the very high pressure generated into the fluid refrigerating circuit.

[0008] In known heat exchangers, the header plate, the distribution plate and the cover are common to the first manifold and the second manifold of the manifold. This configuration induces a thermal coupling between the first manifold and the second manifold of the manifold, thus reducing the thermal efficiency of the heat exchanger, some thermal energy being wasted by a direct transfer from the first manifold to the second manifold, without being used through the heat exchange core of the heat exchanger.

[0009] The above-mentioned heat exchanger has been improved by thermal decoupling of one of the manifolds. The known heat exchanger comprises a thermally decoupled manifolds located in the vicinity of the inlet and the outlet of the heat exchanger.

[0010] The invention aims at proposing a second thermally decoupled manifold with a specific design in order to limit the thermal coupling between its parts, while still resisting to the very high pressure resulting from the use of the super-critical refrigerant fluid and allow the flow of the refrigerant between the rows of tubes.

[0011] Another object of the invention is to provide a heat exchanger in which effective multipass configuration is possible.

SUMMARY OF THE INVENTION

[0012] The object of the invention is a heat exchanger adapted for circulation of a first fluid therein comprising a first manifold group and a second manifold group arranged substantially in parallel with respect to each other, a plurality of tubes extending between the first manifold group and the second manifold group, and a third manifold group arranged either at the level of the first manifold group, or at the level of the second manifold group, also being connected to the plurality of tubes, wherein the tubes are arranged in a first stack and a second stack, the third manifold group enabling a first fluid U-flow therebetween, wherein the first manifold group comprises two primary fluid compartments so that the first primary fluid compartment is connected directly to the first stack, and the second primary fluid compartment is connected directly to the second stack, the first primary fluid compartment comprising a first fluid inlet channel, and the second primary fluid compartment comprising a first fluid

outlet channel, wherein the second manifold group comprises two secondary fluid compartments so that the first secondary fluid compartment is connected directly to the first stack and the second secondary fluid compartment is connected directly to the second stack, wherein an inlet pass is formed between the first fluid inlet channel and the first secondary fluid compartment, and wherein an outlet pass is formed between the second secondary fluid compartment and the first fluid outlet channel.

[0013] Preferably, a pre-return pass is formed within the first stack connected to the third manifold group, and a post-return pass is formed within the second stack connected to the third manifold group.

[0014] Preferably, the inlet pass is followed by the pre-return pass, then the post-return pass, after which proceeds the outlet pass.

[0015] Preferably, the first primary fluid compartment further comprises a first intermediate primary section separated from the first fluid inlet channel, while the second primary fluid compartment further comprises a second intermediate primary section separated from the first fluid outlet channel, wherein a first intermediate pass is formed between the first secondary fluid compartment and the first intermediate primary section, and a second intermediate pass is formed between the second secondary fluid compartment and the second intermediate primary section.

[0016] Preferably, the first intermediate pass is arranged between the inlet pass and the pre-return pass, while the second intermediate pass is arranged between the post-return pass and the outlet pass.

[0017] In one example, the first secondary fluid compartment further comprises a separated intermediate secondary section, while the second secondary fluid compartment further comprises a separated second intermediate secondary section, wherein a third intermediate pass is formed between the first intermediate primary section and the intermediate secondary section, and a fourth intermediate pass is formed between the second intermediate secondary section and the second intermediate primary section.

[0018] Advantageously, the passes are arranged in the subsequent order: the inlet pass, the first intermediate pass, the third intermediate pass the pre-return pass, the post-return pass, the fourth intermediate pass, the second intermediate pass and the outlet pass.

[0019] Preferably, the primary fluid compartments are arranged remote one to another.

[0020] Preferably, the secondary fluid compartments arranged remote one to another.

[0021] Preferably, the third manifold group is a single block adapted to receive tubes of the first stack and the second stack.

[0022] Preferably, one primary fluid compartment is fluidly connected with the greater number of the flat tubes than the other primary fluid compartment.

[0023] Preferably, one secondary fluid compartment is fluidly connected with the greater number of the flat tubes

than the other secondary fluid compartment.

[0024] In one option, the heat exchange can be configured to be an inner gas cooler adapted for the R744 refrigerant as the first fluid.

5 **[0025]** In one option, the heat exchange can be configured to be an inner condenser adapted for R134a or R1234yf refrigerant as the first fluid.

[0026] Another object of the invention is a heating, ventilation and/or air-conditioning system, comprising at least one heat exchanger as described above.

10 **[0027]** According to one of the examples, the heat exchanger may be a heat exchanger adapted for circulation of a first fluid therein comprising a first manifold group and a second manifold group arranged substantially in parallel with respect to each other, a plurality of tubes extending between the first manifold group and the second manifold group, and a third manifold group arranged either at the level of the first manifold group, or at the level of the second manifold group, wherein the tubes are arranged in a first stack and at least one second stack, so that the third manifold group enables a U-flow between at least part of the tubes of the stacks, characterized in that the first manifold group comprises at least two primary fluid compartments arranged remote one to another
15 so that one primary fluid compartment is connected directly to at least part of one stack and the other primary fluid compartment is connected directly to at least part of the other stack, and in that the second manifold group comprises at least two secondary fluid compartments arranged remote one to another so that one primary fluid compartment is connected directly to at least part of one stack and the other primary fluid compartment connected directly to at least part of the other stack.

20 **[0028]** Advantageously, each of the fluid compartments comprises a primary header configured to receive the flat tubes, and a primary cover configured to form a channel for the first fluid.

25 **[0029]** Advantageously, each of the fluid compartments further comprises a primary distribution plate sandwiched between the primary header, and the primary cover.

30 **[0030]** Advantageously, the third manifold group comprises a secondary header configured to receive the flat tubes, and a secondary cover configured to form a channel for the first fluid.

35 **[0031]** Advantageously, the third manifold group further comprises a secondary distribution plate sandwiched between the secondary header, and the secondary cover.

40 **[0032]** Advantageously, the primary cover provides a channel for the first fluid between the tubes arranged within the same stack whereas the secondary cover provides a channel for the first fluid between the tubes of the first stack and the second stack.

45 **[0033]** Advantageously, the primary distribution plate enables a direct fluid communication between an individual tube among the plurality of tubes and the channel for the first fluid formed within the primary cover, whereas

the secondary distribution plate enables a direct fluid communication between at least two individual tubes of the neighboring stacks.

[0034] Advantageously, the primary distribution plate comprises at least one inlet to form an inlet channel within one primary fluid compartment, and at least one outlet to form an outlet channel within the other primary fluid compartment.

[0035] Advantageously, the tubes can be fluidly connected with the manifold groups form four passes for the first fluid.

[0036] Advantageously, the tubes can be fluidly connected with the manifold groups form at least six passes for the first fluid.

[0037] Advantageously, each primary header comprises a set of primary protrusions protruding towards the primary cover, wherein the primary protrusions are formed substantially beyond the outline of said primary cover.

[0038] Advantageously, the secondary header comprises a set of secondary protrusions protruding towards the secondary cover, wherein the secondary protrusions are formed substantially beyond the outline of said secondary cover.

[0039] Advantageously, the third manifold group is made in one piece with any of the first manifold group or the second manifold group.

BRIEF DESCRIPTION OF DRAWINGS

[0040] Examples of the invention will be apparent from and described in detail with reference to the accompanying drawings, in which:

Fig. 1 shows a perspective view of the heat exchanger.

Fig. 2 shows a heat exchanger of Fig.1 in a different perspective.

Fig. 3 shows an exploded view of the heat exchanger of Figs 1 and 2.

Fig. 4 shows a schematic path for the fluid within a heat exchanger comprising four passes for the fluid.

Fig. 5 shows a schematic path of the fluid within a heat exchanger comprising six passes for the fluid.

Figs. 6a and 6b show a schematic path for the fluid within a heat exchanger comprising four passes for the fluid according to another example.

Figs. 7a and 7b show a schematic path for the fluid within a heat exchanger comprising six passes for the fluid according to another example.

Fig. 8 shows a schematic path for the fluid within a

heat exchanger comprising eight passes for the fluid according to another example.

DETAILED DESCRIPTION OF EMBODIMENTS

[0041] The subject-matter of an invention is a heat exchanger 1. The heat exchanger 1 is adapted for heat exchange between a first fluid and a second fluid. The first fluid may be for, example pressurized refrigerant such as carbon-dioxide circulating within the heat exchanger 1, whereas the second fluid may be, for example air travelling between the tubes of the heat exchanger from one side of the heat exchanger to the other. The heat exchanger 1 aims to decrease the temperature of the first fluid. It can therefore be associated with the gas coolers, inner gas coolers, evaporators and alike. Further paragraphs provide discuss the main components and the mechanical or structural features, which ensure improvement in terms of efficiency with respect to know heat exchangers.

[0042] As shown in Fig. 1, the heat exchanger 1 may comprise a first manifold group 100 and a second manifold group 200. Term "manifold group" may refer to one or more manifolds arranged in the vicinity one to another. For example, "first manifold group" may refer to two manifolds arranged next to each other, wherein these manifolds share the same structural features. The first manifold group 100 and the second manifold group 200 may be arranged substantially in parallel with respect to each other, as shown in the figures. The second manifold group 200 is located oppositely with respect to the first manifold group 100. However, the first and the second manifold groups 100, 200 may exhibit the same structural features, despite the differences in their relative location and orientation with respect to each other.

[0043] The heat exchanger 1 may further comprise a plurality of tubes 500 extending between the first manifold group 100 and the second manifold group 200. Term "tubes" refers to a group of tubes, which may be formed by two or more individual tubes 500A. Further, term tubes may refer to total number of tubes 500 of the heat exchanger 1 or some part of them. Nevertheless, if only part of the tubes 500 is to be described, it will be clearly indicated in the description. The tubes may be formed either in the process of extrusion, or by roll-forming, depending on the desired characteristics of the heat exchanger 1 and the characteristics of the first fluid. The tubes 500 may comprise two open ends to allow the first fluid flow there-through. The tubes 500 may also comprise an axis of elongation. The axis of elongation of the tubes 500 may be indicated as a general axis between their open ends. The tubes 500 may be formed in a first stack 501 and at least one second stack 502. Both the first stack 501 and the second stack 502 may comprise its individual stacking direction, wherein the stacking direction is substantially perpendicular to the axis of elongations of the tubes 500 forming the first stack 501 and the second stack 502, respectively.

[0044] Fig. 2 shows different perspective view of the heat exchanger 1. The heat exchanger 1 may further comprise a third manifold group 300 arranged either at the level of the first manifold group 100, or at the level of the second manifold group 200. Fig. 2 depicts an example in which the third manifold group 300 is at the same level as the second manifold group 200. The first manifold group 100 is located on the opposite side to the second manifold group 200 and the third manifold group 300, with respect to the tubes 500. An example in which the third manifold group 300 is at the same level as the first manifold group 100 and the second manifold group 200 is opposite to the latter is also envisaged and described in further paragraphs.

[0045] The third manifold group 300 is configured in a way that enables a U-flow between at least part of the tubes 500 of the stacks 501, 502. In other words, the third manifold group 300 is fixed directly to the tubes 150 forming the first stack 501 and the second stack 502. Preferably, the third manifold group 300 is a single element in a sense it is dedicated directly to receive two stacks 501, 502 as a one integral structure without subcomponents being remote to each other.

[0046] The first manifold group 100 may comprise at least two primary fluid compartments 101A, 101B. The term "fluid compartment" refers to all structural elements, which allow to provide a conduit for the fluid, namely the first fluid. The first fluid compartment 101A and the second fluid compartment 101B may be arranged remote one to another so that one primary fluid compartment 101A is connected directly to at least part of one stack 501 and the other primary fluid compartment 101B is connected directly to at least part of the other stack 502. Similarly, the second manifold group 200 may comprise at least two secondary fluid compartments 201A, 201B arranged remote one to another so that one secondary fluid compartment 201A is connected directly to at least part of one stack 501 and the other secondary fluid compartment 201B connected directly to at least part of the other stack 502. By the term 'remote to one other' it is understood that the components are substantially physically separate, thereby limiting heat exchange therebetween. In other words, they are not made of a single component, e.g. a single block with multiple channels therein. In one example, the components remote to one another are distanced with respect to each other while still being immobilized with respect to each other through other elements.

[0047] Conspicuously, the third manifold group 300 differs from the primary and the secondary fluid compartments 101A, 101B, 201A, 201B in that it is fixed directly to both stacks 501, 502, whereas each fluid compartment 101A, 101B, 201A, 201B is fixed only to one of the stacks 501, 502.

[0048] Fig. 3 shows an exploded perspective view of the exemplary heat exchanger 1 comprising sub-components which may be used, for example, in the manifold groups 100, 200, 300. Since the manifold groups 100,

200 are very similar, the features described based on the sub-components of the first manifold group 100 also apply to the sub-components of the second manifold group 200.

[0049] As shown in Fig. 3, each fluid compartment 101A, 101B, 201A, 201B being part of the first and/or second manifold group 100, 200, may comprise a primary header 110, and a primary cover 120 configured to form a channel for the first fluid. The channel for the fluid should be understood as the conduit formed by the channel, which allows distributing or collecting the first fluid from the consecutive tubes 500 of the stack 501, 502 in the vicinity of which said cover 120 is located.

[0050] The primary header 110 may be configured to receive the flat tubes 500. The tubes 500 may be received in plurality of slots. Each slot may receive at least part of one end of the individual tube 500A.

[0051] Each of the fluid compartments 101A, 101B, 201A, 201B may further comprise a primary distribution plate 130 sandwiched between respective primary header 110, and the primary cover 120. The primary distribution plate 130 forms a channel for the first fluid between the primary header 110 and the primary cover 120 of respective fluid compartment 101A, 101B, 201A, 201B. In other words, the distribution plate 130 may be an extension of the fluidal conduit providing a fluidal communication between the open end of the tube 500 and the cover 120. It is to be noted that the primary distribution plates 130 comprise openings for receiving at least part of the tubes 500 arranged in the same stack 501, 502.

[0052] Analogically, to the first manifold group 100 and the second manifold group 200, the third manifold group 300 may comprise a secondary header 310 configured to receive the flat tubes 500, and a secondary cover 320 configured to form a channel for the first fluid. However, despite the similarities in number of the sub-components, the third manifold group 300 serves different purpose than the first manifold group 100 and the second manifold group 200.

[0053] The third manifold group 300 may comprise a secondary distribution plate 330 sandwiched between the secondary header 310, and the secondary cover 320. The secondary distribution plate 330 may comprise openings which are configured to provide a channel for the first fluid between the tubes 500 of the neighboring stacks 501, 502. Similar fluidal communication may also be carried out by the secondary cover, yet as shown in Fig. 3, the channels for the first fluid formed on the secondary cover may be configured in parallel to the stacking direction of the stack 501, 502. The openings of the secondary distribution plate may be arranged in perpendicular to the stacking direction of the tubes 500 and in parallel to axis of elongation of the tubes 500. As shown in Fig. 3, the openings of the secondary distribution plate 330 may be configured to fluidly communicate two tubes 500, wherein one tube 500 belongs to one stack 501 and the other tube 500 belongs to the other stack 502, however, the forms and shapes of the openings within the

secondary distribution plate 330 providing other configurations are also envisaged.

[0054] As a consequence, the primary cover 120 may provide a channel for the first fluid between the tubes 500 arranged within the same stack 501, 502 whereas the secondary cover 220 provides a channel for the first fluid between the tubes 500 of the first stack 501 and the second stack 502.

[0055] Furthermore, the primary distribution plate 130 may enable a direct fluid communication between the individual tube 500a among the plurality of tubes 500 and the channel for the first fluid formed within the primary cover 120, whereas the secondary distribution plate 330 enables a direct fluid communication between at least two individual tubes 500a of the neighboring stacks 501, 502.

[0056] The heat exchanger 1 may comprise an inlet and an outlet for the first fluid. Both inlet and outlet may be in form of openings fluidly connected to respective pipes of the refrigerant loop. The openings may also be connected indirectly, for example by means of connection block or other types of connectors. The pipes or the connection blocks may be fixed wherever suitable, depending on desired flow pattern or location of the inlet and outlet.

[0057] One of possible examples is shown in Fig. 3, wherein the primary distribution plate 130 may comprise at least one inlet 180 in form of the opening and at least one outlet 190. The inlet 180 may be fluidly connected directly to an inlet channel 180A within one primary fluid compartment 101A, and at least one outlet 190 to form an outlet channel 190A within the other primary fluid compartment 101B. In other words, the fluid channels fluidly connected directly to the inlet and/or outlet 190 may be called inlet channel 180A and outlet channel 190A, respectively. As shown in Fig. 3 the inlet 180 may be located on the end of the primary distribution plate 130 of one primary fluid compartment 101A, whereas the outlet 190 may be located on the end of the primary plate 130 of the other primary fluid compartment 101B. Thus, primary fluid compartment 101A may form inlet channel 180A whereas the other primary fluid compartment 101B may form the outlet channel 190A. As shown in Fig. 3, the total length of the primary distribution plates 130 along with the total length of primary covers 120 may be greater than total length of the primary headers 110.

[0058] In order to improve heat exchange between the first fluid and the second fluid the heat exchanger 1 may comprise passes. The term "pass" means a group or subgroup of tubes 500 in which the fluid follows one and the same direction and in one and the same sense. When passing from one pass to the other, the direction of first fluid flow is reversed. This makes it possible to lengthen the path of the first fluid in the exchanger 1.

[0059] Fig. 4 shows a perspective view of the heat exchanger 1 comprising four passes P_{in}, P_{u1}, P_{u2}, P_{out} for the first fluid. The flow path of the first fluid is indicated by solid and dashed lines, whereas the direc-

tion of flow is indicated by arrows. The first fluid enters the heat exchanger 1 through the inlet 180, which is indicated by an arrow. Next, it flows through the inlet channel 180A of the first manifold group 100. The part of the first stack 501, which is fluidly connected to the inlet channel 180A, forms an inlet pass P_{in} that conveys the first fluid towards the first secondary fluid compartment 201A of the second manifold group 200. The first secondary fluid compartment 201A forms a channel for the first fluid to convey it to the other part of the first stack 501. Next, the first fluid flows towards the third manifold group 300 through a pre-return pass P_{u1} formed in the other part of the first stack 501. The third manifold group 300 provides a U-flow, so that the pre-return pass P_{u1} is fluidly connected with a post-return pass P_{u2}, which is formed by a part of the second stack 502. The first fluid is conveyed in parallel to the stacking direction by the channel formed in the second secondary fluid compartment 201B. Next, the first fluid enters an outlet pass P_{out}, which fluidly communicates part of the second secondary fluid compartment 201B with part of the outlet channel 190A, formed within the second primary fluid compartment 101A. The first fluid flows out from the heat exchanger through the outlet 190, which is indicated by the arrow.

[0060] As shown in Fig. 5, tubes 500 may be fluidly connected with the manifold groups 100, 200, 300 form at least six passes P_{in}, P_{i1}, P_{u1}, P_{u2}, P_{i2}, P_{out} for the first fluid. The flow path of the first fluid is indicated by solid and dashed lines, whereas the direction of flow is indicated by arrows. The first fluid enters the heat exchanger 1 through the inlet 180. Next, it flows through the inlet channel 180A of the first primary fluid compartment 101A. The part of the first stack 501, which is fluidly connected to the inlet channel 180A, forms an inlet pass P_{in} that conveys the first fluid towards the first secondary fluid compartment 201A. The first secondary fluid compartment 201A forms a channel for the first fluid to convey it to the other part of the first stack 501. Next, the first fluid flows towards a first intermediate primary section 102A of the primary fluid compartment 101A through a first intermediate pass P_{i1} formed in the other part of the first stack 501. The first intermediate primary section 102A conveys the first fluid towards the third manifold group 300 through a pre-return pass P_{u1} formed in the next part of the first stack 501. The third manifold group 300 provides a U-flow, so that the pre-return pass P_{u1} is fluidly connected with a post-return pass P_{u2} which is formed by part of the second stack 502. The post-return pass P_{u2} conveys the first fluid towards a second intermediate primary section 102B of the second primary fluid compartment 101B and it is conveyed in parallel to the stacking direction by the channel formed therein. Next, the first fluid enters a second intermediate pass P_{i2} which fluidly communicates the second intermediate primary section 102B of the second primary fluid compartment 101B with part of the second secondary fluid compartment 201B. Subsequently, part of the second secondary fluid compartment 201B conveys the first fluid

towards the outlet channel 190A formed within by part of the second primary fluid compartment 101B in an outlet pass P_{out}. The first fluid flows out from the heat exchanger through the outlet 190.

[0061] Because the refrigerant mass flow is usually a fixed parameter in a vehicle heat pump system, such increase of the number of passes allows to prolong the time when refrigerant subject to heat exchange with air travelling between the tubes.

[0062] Additionally, as pressure delta is very low the heat transfer coefficient increases significantly with the increase of refrigerant velocity. Because the length of the refrigerant travel throughout the proposed heat exchangers is increased, so is its velocity. This leads to a more effective heat exchange, in particular in the designs proposing 6 passes or even 8 passes.

[0063] In order to facilitate assembly of the primary fluid compartments 101A, 101B, 201A, 201B, the primary headers 110 may comprise a set of primary protrusions 111 protruding towards the primary cover 120. The primary protrusions 111 may be formed substantially beyond the outline of said primary cover 120. In other words, the primary protrusions 111 allow contact between the surface of the primary header 110 and the primary cover 120, so that the channel for the fluid may be formed therein. Next, the primary protrusions 111 may be crimped over the primary cover 120. Same applies to the protrusions described in further paragraphs.

[0064] Similarly, the secondary header 210 may comprise a set of secondary protrusions 211 protruding towards the secondary cover 220. The secondary protrusions 211 may be formed substantially beyond the outline of said secondary cover 220.

[0065] In this configuration, the linking elements in form of protrusions 111, 211 are thus localized between the primary fluid compartments 101A, 101B and secondary fluid compartments 201A, 201B. This configuration creates a gap between these elements allowing a total thermal decoupling of the heat exchanger. More precisely, the primary header 110 of the first primary fluid compartment 101A is separated from the primary header 110 of the other primary fluid compartment 101B by the gap. Similar configuration applies to the secondary fluid compartments 201A, 201B and its sub-components. Such configuration thus allows an improved thermal efficiency of both first manifold group 100 and the second manifold group 200. Additionally, less calories being transferred directly between the first manifold and the second manifold compared to a known configuration of a manifold.

[0066] The mechanical link allows the primary fluid compartment 101A to keep its relative position with respect to the other primary fluid compartment 101B. Similarly, the mechanical link allows the secondary fluid compartment 201A to keep its relative position with respect to the other secondary fluid compartment 201B.

[0067] With regards to the architecture of the heat exchanger, the thickness of respective passes may vary. The thickness of the pass should be understood as the

number of the flat tubes forming said pass. In one example, one primary fluid compartment 110A is fluidly connected with the greater number of the flat tubes 500 than the other primary fluid compartment 110B. In another option, all passes comprise the same thickness. Alternatively, at least one pass has different thickness than the other passes. Alternatively, all passes have different thickness. However, it is to be noted that total thickness of the passes within the first stack 501 is preferably equal to total thickness of the passes within the second stack 502.

[0068] Consequently, the fluid compartments 101A, 101B, 201A, 201B may vary between each other in terms of size.

[0069] For example, one primary fluid compartment 101A may be fluidly connected with the greater number of the flat tubes 500 than the other primary fluid compartment 101B. Consequently, one primary fluid compartment 101A may be bigger than the other 101B

[0070] Further, the third manifold group 300 may be made in one piece with any of the first manifold group 100 or the second manifold group 200. It means that there may be a mechanical link between the manifold groups 100, 200, 300.

[0071] Figs. 6a, 6b, 7a, 7b present another example of a heat exchanger according to the invention. In particular, they show a heat exchanger configured to be an inner condenser adapted for R134a or R1234yf refrigerant as the first fluid. The fluid compartments can be defined using bigger plates with stamped shapes delimiting channels, as the operating pressure is lower than in case of R744 refrigerant. Otherwise, the structure may remain substantially similar to that described above.

[0072] Figs. 6a and 6b show a schematic path for the fluid within a heat exchanger comprising four passes for the fluid according to another example. The passes are organized in the same manner as shown in the example heat exchanger of Fig. 4.

[0073] Figs. 7a and 7b show a schematic path for the fluid within a heat exchanger comprising six passes for the fluid according to another example. The passes are organized in the same manner as shown in the example heat exchanger of Fig. 5.

[0074] Fig. 8 shows a schematic path for the fluid within a heat exchanger (100) comprising eight passes for the fluid according to another example. This configuration is particularly beneficial for inner condensers adapted for R134a or R1234yf refrigerant as the first fluid. In addition to the heat exchanger shown in Figs 7a and 7b, the first secondary fluid compartment 201A further comprises a separated intermediate secondary section 202A, while the second secondary fluid compartment 201B further comprises a separated second intermediate secondary section 202B. A third intermediate pass P_{i3} is formed between the first intermediate primary section 102A and the intermediate secondary section 202A, and a fourth intermediate pass P_{i4} is formed between the second intermediate secondary section 202B and the second in-

intermediate primary section 102B.

[0075] In the abovementioned configuration the passes are arranged subsequent order: the inlet pass P_{in}, the first intermediate pass P_{i1}, the third intermediate pass P_{i3} the pre-return pass P_{u1}, the post-return pass P_{u2}, the fourth intermediate pass P_{i4}, the second intermediate pass P_{i2} and the outlet pass P_{out}. Such arrangement further amplifies beneficial fluid path for the refrigerant to maximize heat exchange efficiency.

[0076] Other variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing the claimed invention, from a study of drawings, the disclosure, and the appended claims. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to the advantage.

Claims

1. A heat exchanger (1) adapted for circulation of a first fluid therein comprising a first manifold group (100) and a second manifold group (200) arranged substantially in parallel with respect to each other, a plurality of tubes (500) extending between the first manifold group (100) and the second manifold group (200), and a third manifold group (300) arranged either at the level of the first manifold group (100), or at the level of the second manifold group (200), also being connected to the plurality of tubes (500), wherein the tubes (500) are arranged in a first stack (501) and a second stack (502), the third manifold group (300) enabling a first fluid U-flow therebetween, wherein the first manifold group (100) comprises two primary fluid compartments (101A, 101B) so that the first primary fluid compartment (101A) is connected directly to the first stack (501), and the second primary fluid compartment (101B) is connected directly to the second stack (502), the first primary fluid compartment (101A) comprising a first fluid inlet channel (180A), and the second primary fluid compartment (101B) comprising a first fluid outlet channel (190A), wherein the second manifold group (200) comprises two secondary fluid compartments (201A, 201B) so that the first secondary fluid compartment (201A) is connected directly to the first stack (501) and the second secondary fluid compartment (201B) is connected directly to the second stack (502), wherein an inlet pass (P_{in}) is formed between the first fluid inlet channel (180A) and the first secondary fluid compartment (201A), and wherein an outlet pass (P_{out}) is formed between the second secondary fluid compartment (201B) and the first fluid outlet channel (190A).
2. The heat exchanger (1) according to claim 1, wherein a pre-return pass (P_{u1}) is formed within the first

stack (501) connected to the third manifold group (300), and a post-return pass (P_{u2}) is formed within the second stack (502) connected to the third manifold group (300).

3. The heat exchanger (1) according to claim 2, wherein the inlet pass (P_{in}) is followed by the pre-return pass (P_{u1}), then the post-return pass (P_{u2}), after which proceeds the outlet pass (P_{out}).
4. The heat exchanger (1) according to claim 2 or 3, wherein the first primary fluid compartment (101A) further comprises a first intermediate primary section (102A) separated from the first fluid inlet channel (180A), while the second primary fluid compartment (101B) further comprises a second intermediate primary section (102B) separated from the first fluid outlet channel (190A), wherein a first intermediate pass (P_{i1}) is formed between the first secondary fluid compartment (201A) and the first intermediate primary section (102A), and a second intermediate pass (P_{i2}) is formed between the second secondary fluid compartment (201B) and the second intermediate primary section (102B).
5. The heat exchanger (1) according to claim 4, wherein the first intermediate pass (P_{i1}) is arranged between the inlet pass (P_{in}) and the pre-return pass (P_{u1}), while the second intermediate pass (P_{i2}) is arranged between the post-return pass (P_{u2}) and the outlet pass (P_{out}).
6. The heat exchanger (1) according to claim 4 or 5, wherein the first secondary fluid compartment (201A) further comprises a separated intermediate secondary section (202A), while the second secondary fluid compartment (201B) further comprises a separated second intermediate secondary section (202B), wherein a third intermediate pass (P_{i3}) is formed between the first intermediate primary section (102A) and the intermediate secondary section (202A), and a fourth intermediate pass (P_{i4}) is formed between the second intermediate secondary section (202B) and the second intermediate primary section (102B).
7. The heat exchanger (1) according to claim 6, wherein passes are arranged in the subsequent order: the inlet pass (P_{in}), the first intermediate pass (P_{i1}), the third intermediate pass (P_{i3}) the pre-return pass (P_{u1}), the post-return pass (P_{u2}), the fourth intermediate pass (P_{i4}), the second intermediate pass (P_{i2}) and the outlet pass (P_{out}).
8. The heat exchanger (1) according to any preceding claim, wherein the primary fluid compartments (101A, 101B) are arranged remote one to another.

9. The heat exchanger (1) according to any preceding claim, wherein the secondary fluid compartments (201A, 201B) arranged remote one to another.
10. The heat exchanger (1) according to any preceding claim, wherein the third manifold group (300) is a single block adapted to receive tubes of the first stack (501) and the second stack (502). 5
11. The heat exchanger (1) according to any of the preceding claims, wherein one primary fluid compartment (110A) is fluidly connected with the greater number of the flat tubes (500) than the other primary fluid compartment (110B). 10
12. The heat exchanger (1) according to any of the preceding claims, wherein one secondary fluid compartment (201A) is fluidly connected with the greater number of the flat tubes (500) than the other secondary fluid compartment (110B). 15 20
13. The heat exchanger (1) according to any preceding claim, configured to be an inner gas cooler adapted for the R744 refrigerant as the first fluid. 25
14. The heat exchanger (1) according to any preceding claim, configured to be an inner condenser adapted for R134a or R1234yf refrigerant as the first fluid.
15. A heating, ventilation and/or air-conditioning system, comprising at least one heat exchanger (1) according to any of the preceding claims. 30

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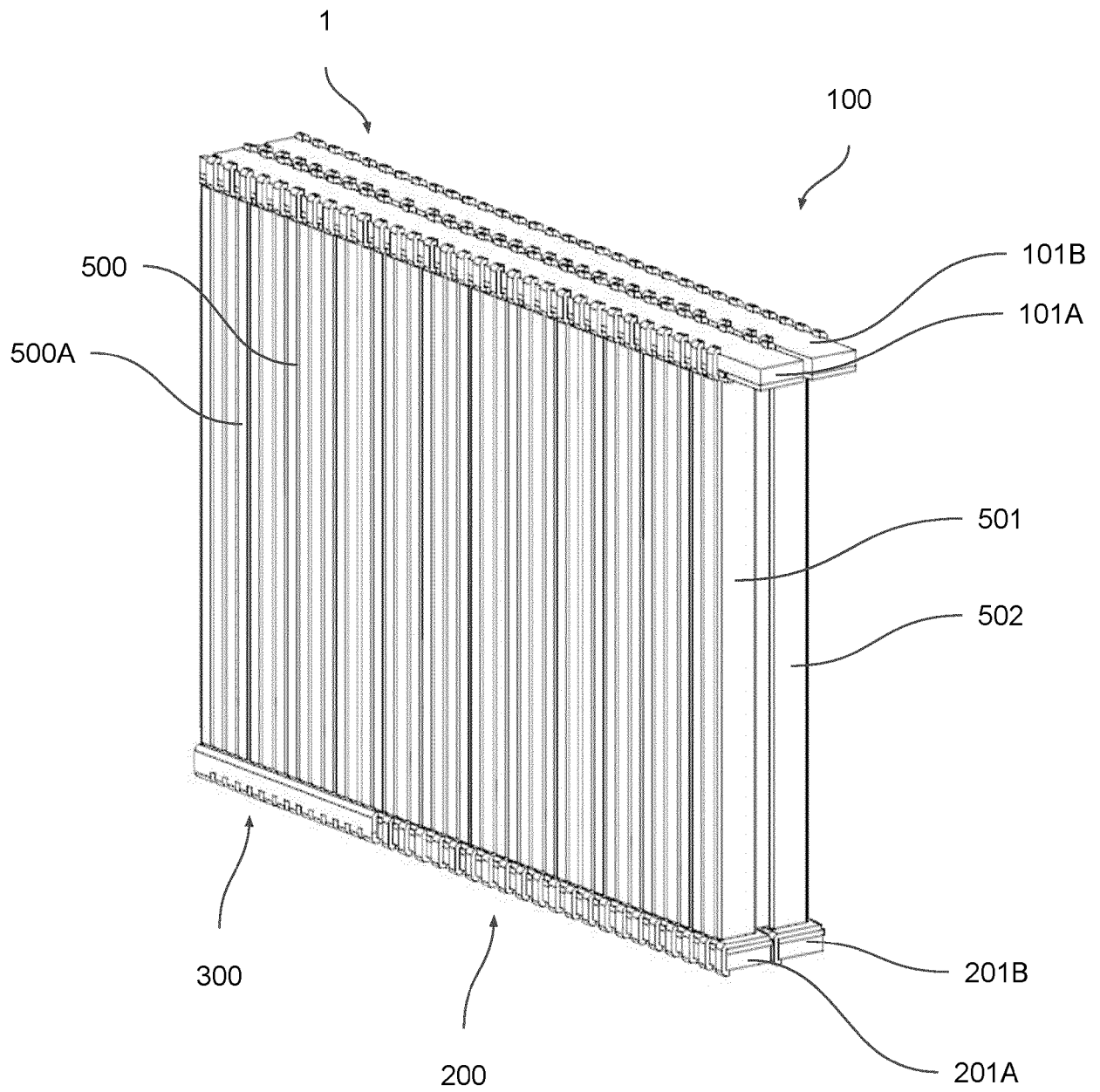


Fig. 1

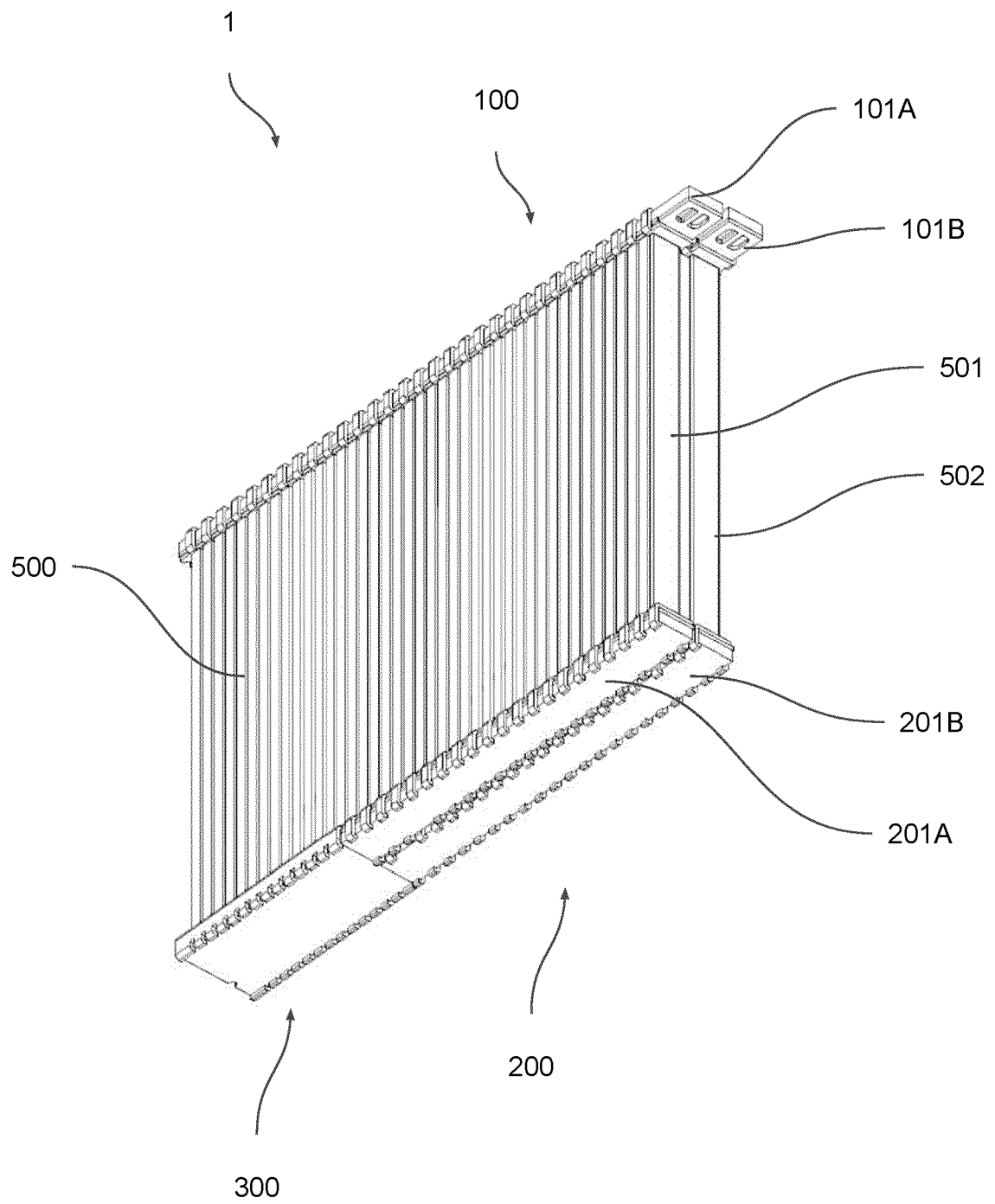


Fig. 2

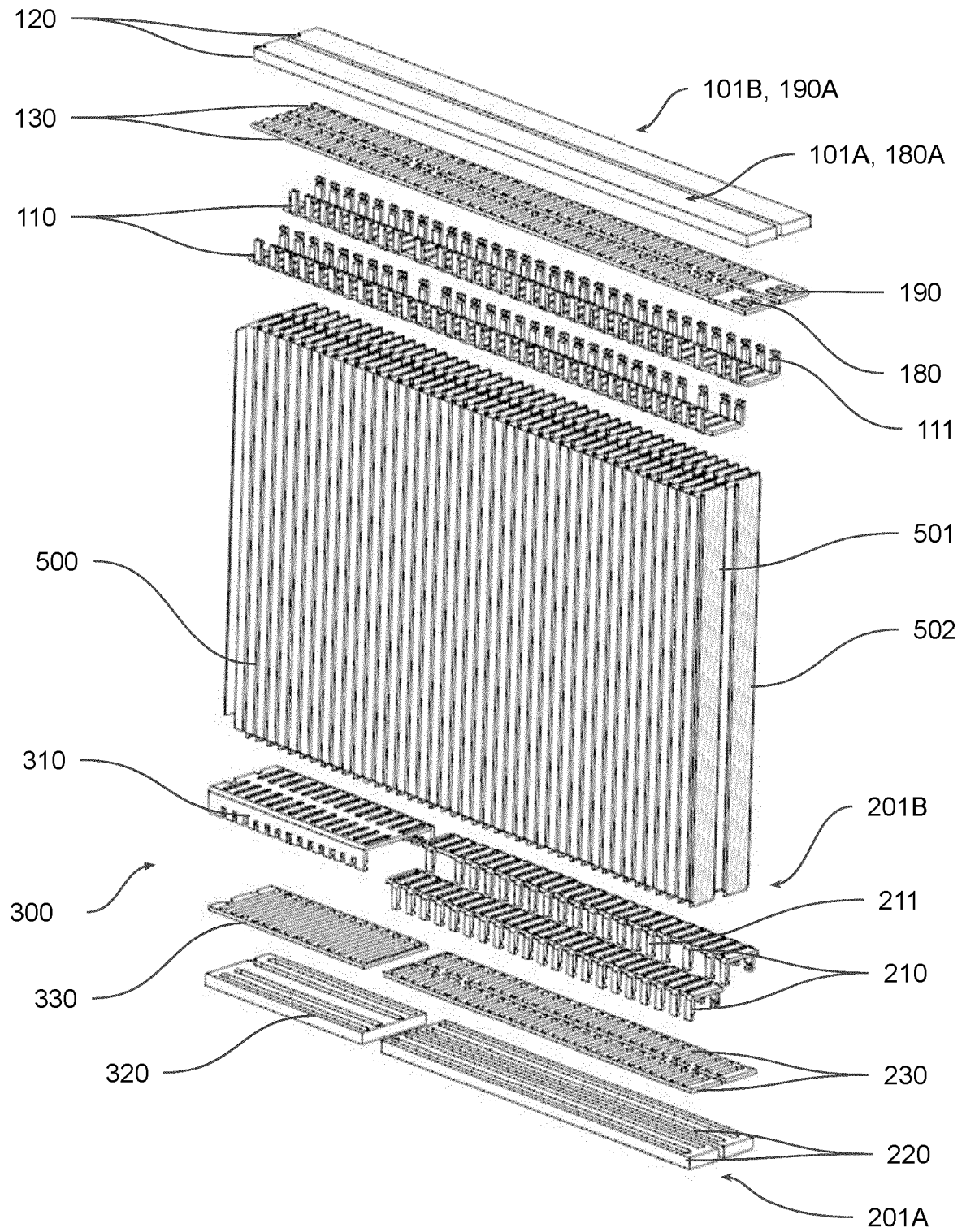


Fig. 3

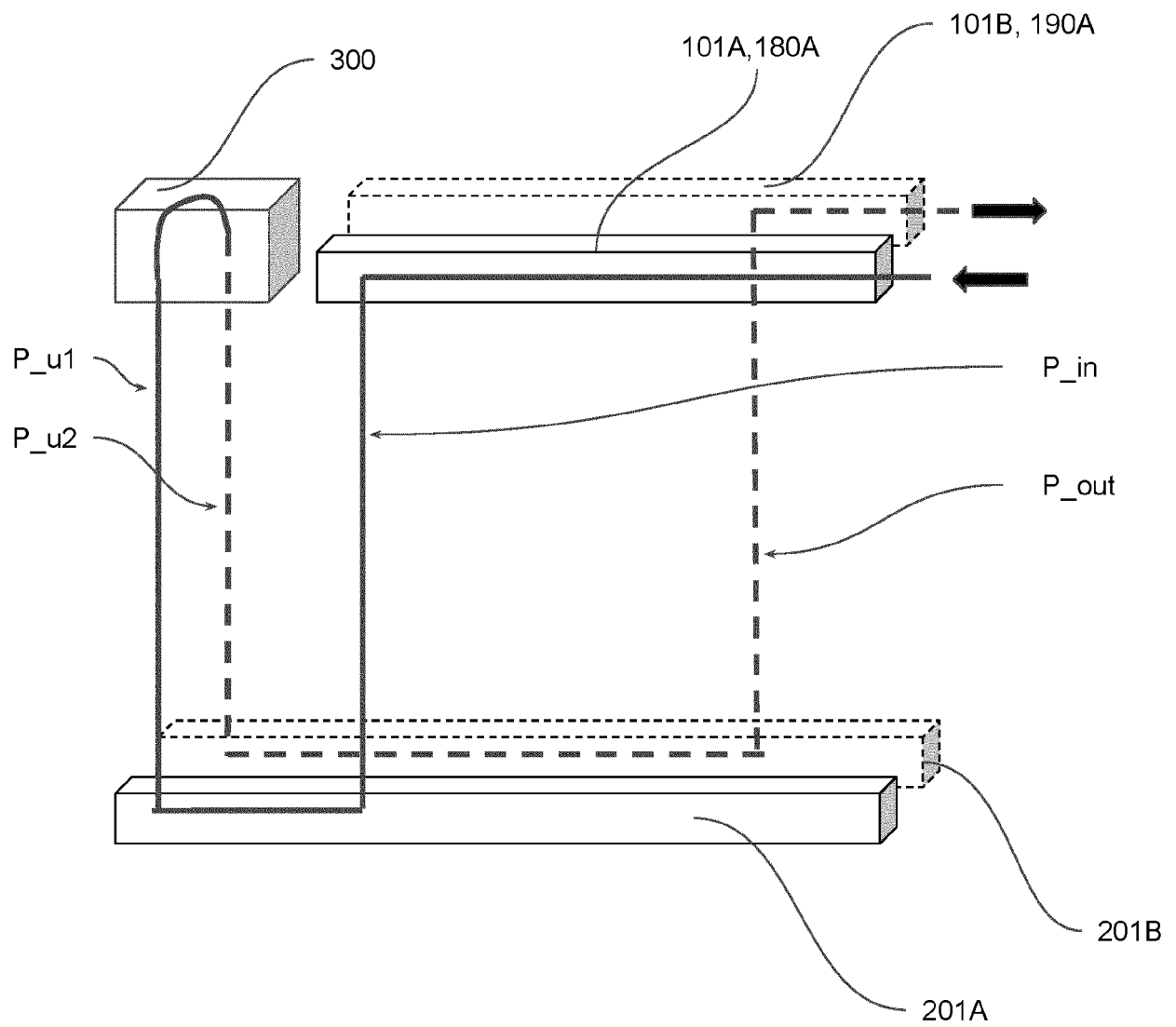


Fig. 4

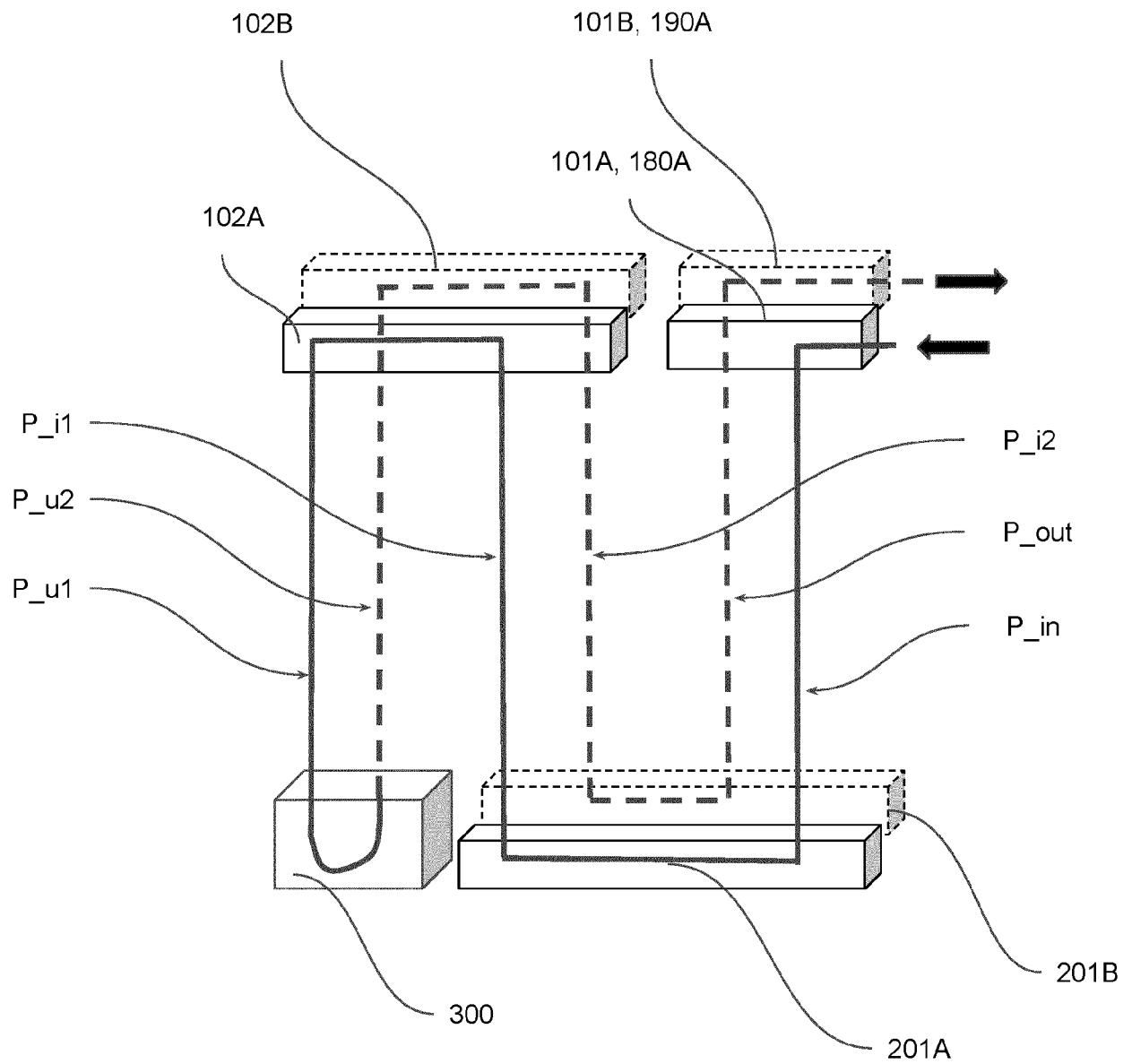


Fig. 5

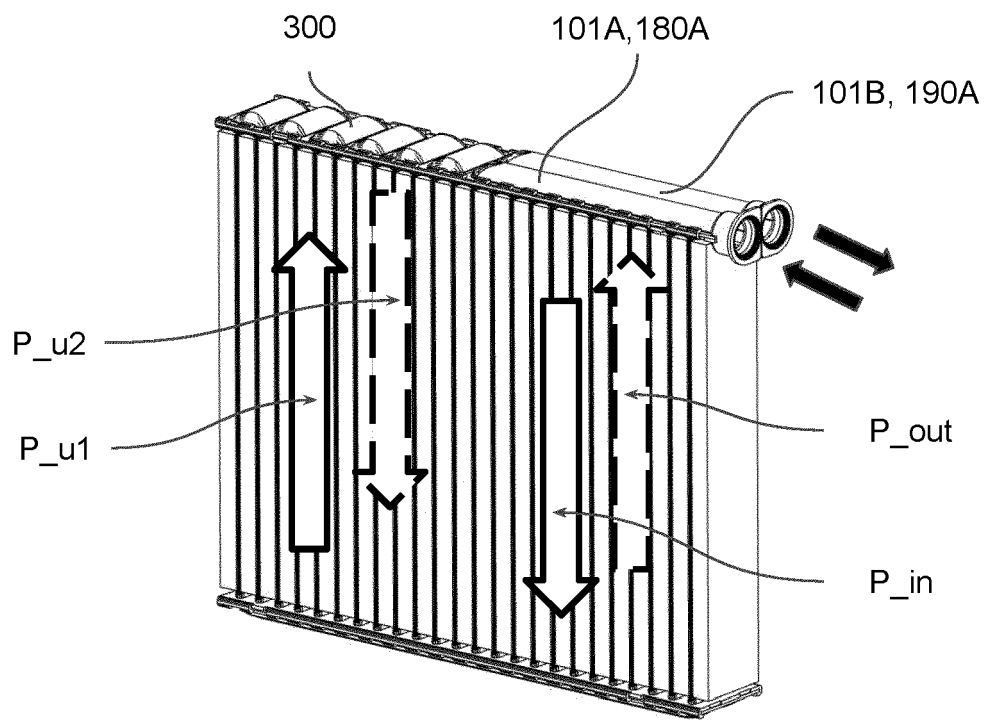


Fig. 6a

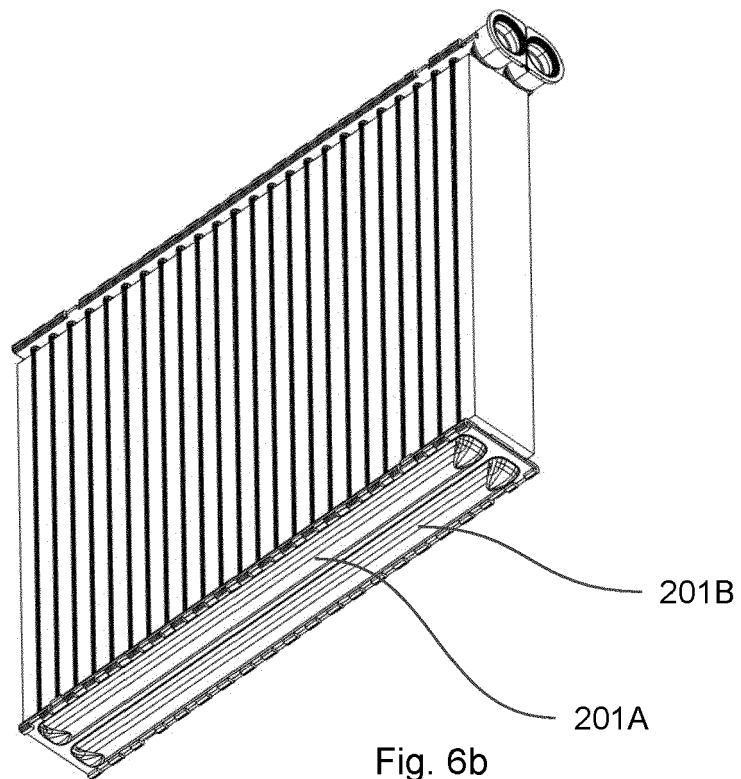


Fig. 6b

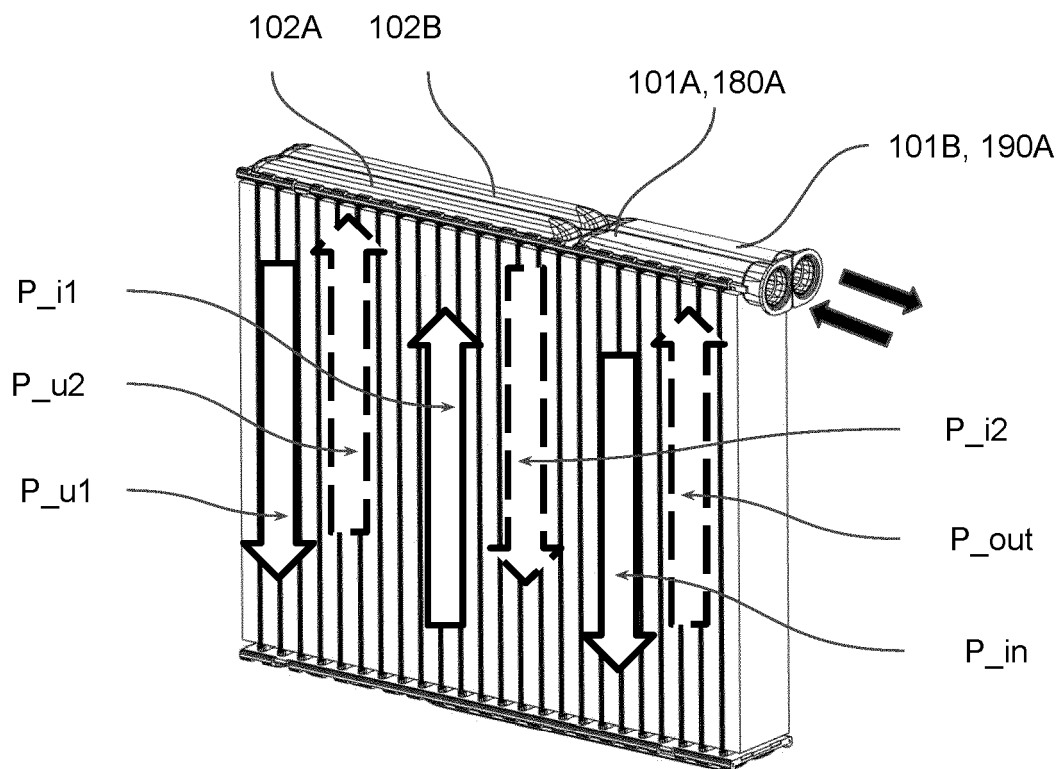


Fig. 7a

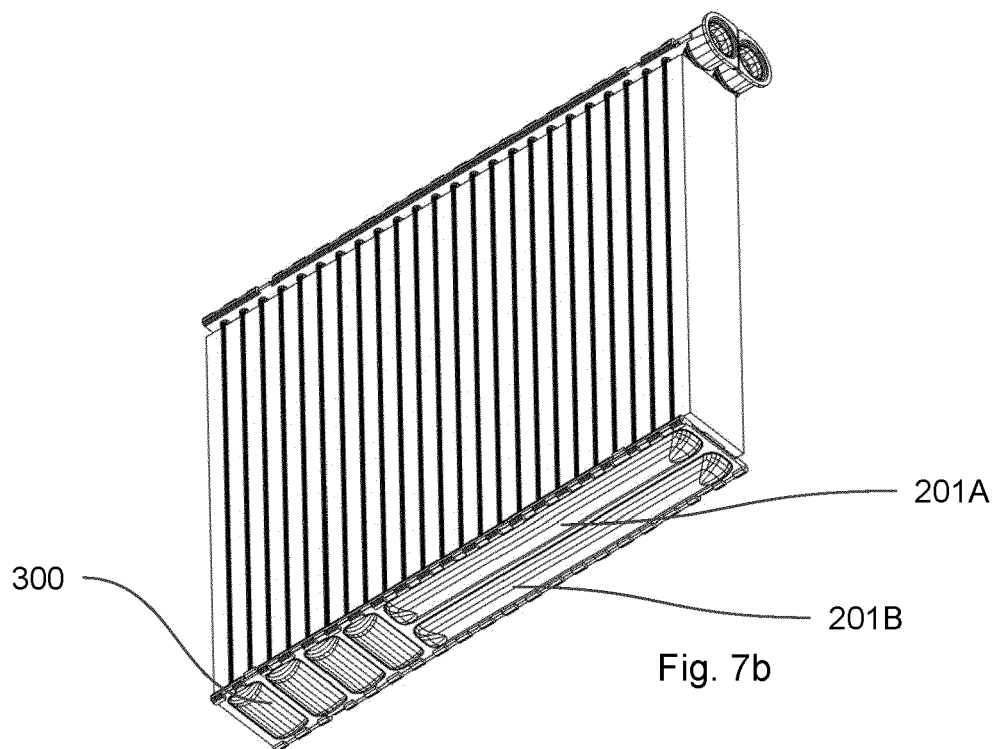


Fig. 7b

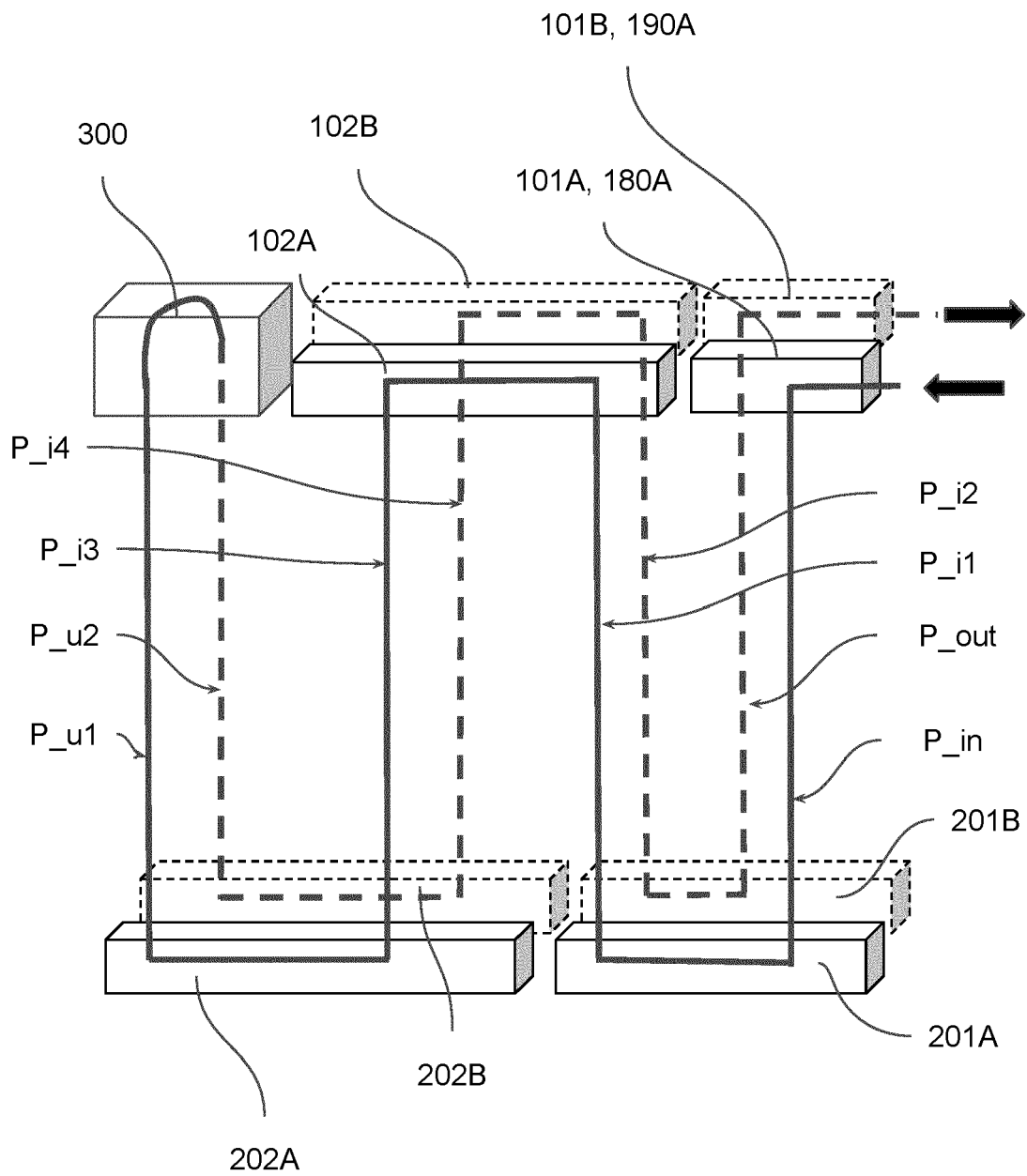


Fig. 8



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Place of search Munich		Date of completion of the search 18 May 2022	Examiner Vassoille, Bruno
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